VIBRATION CONTROL ON HAND-HELD INDUSTRIAL POWER TOOLS

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Introduction

Work with hand-held power tools can be found in most industries all over the world. This type of work exposes the operators to different kind of loads like gripping-forces, feed-forces, exposure to vibration and noise, holding hot or cold surfaces and the exposure to dust. Designing a power tool with good ergonomics is a matter of finding the best compromise. As a simple example, increasing the mass is not acceptable because it will increase the forces needed to handle the tool. At the same time increased mass will in most cases reduce the vibrations.

Vibration disorders related to the use of hand-held power tools has been known and reported since long. It is therefore essential that low vibrating tools are developed and used. The new vibration regulations in Europe, based on the Physical Agents (Vibration) Directive, have put increased focus on the vibration control in industry.

Forces acting on the tool cause vibration

Tools for industrial use must be of very robust design to withstand the very hard use they are exposed to. Industrial tools are therefore normally designed with the main parts made of metal. From a vibration point of view this means that most tools can be regarded as rigid bodies, especially because the dominating frequency normally is equal to the rotational frequency of the tool spindle or the blow frequency for a percussive tool. These frequencies are with few exceptions below 200 Hz. Handles however can not always be regarded as rigidly connected to the tool. There are several examples of weak suspensions designed to reduce vibration transmitted to the hands of the operator. There are also examples of designs where the handles just happened to be non-rigidly connected and in some cases even in resonance within the frequency region of interest. Oscillating forces act on the tool and the result is vibration.

Design principals

In all cases forces are the source of vibration. This leads to the three basic principles to control vibration:

- **Control the magnitude of the vibrating forces**. Examples are the balancing unit on a grinder or the differential piston in a chipping hammer.
- **Make the tool less sensitive to the vibrating forces**. Examples can be when the mass of the guard on a grinder is rigidly connected to the tool to increase the inertia of the tool.
- **Isolate the vibrations in the tool from the grip surfaces.** Examples are vibration-dampening handles on grinders or pavement breakers, the air-spring behind the blow-mechanism in a riveting hammer or the mass spring system in a chipping hammer.

Control the magnitude of the vibrating forces

For rotating machinery the balance of the rotating parts is essential. The inserted tools that will be mounted on the tool spindle often give major contribution to the unbalance of the rotating parts. This is a problem because the tool manufacturer has no control over the inserted tools. The only thing that can be done is to design flanges and guides to fine tolerances as close as possible to the tolerance interval for the inserted tool.

Limiting the power of the tool will in most cases also reduce vibration but that is not a possible route because lower power leads to increased usage-time to get the job done and that would negatively affect the daily exposure.

Make the tool less sensitive to the vibrating forces

A tool will be less sensitive to oscillating forces when mass and or inertia is increased. To increase mass can be questioned from an ergonomic perspective. In some cases when a small increase in mass give a big increase in inertia it might still be a good solution. The tool can be regarded as a rigid body suspended in weak springs. Therefore it will move around its centre of rotation. The perpendicular distance between the forces acting and the centre of rotation will determine how the pattern of movement will be. By altering this distance the movement of the tool can be controlled.

Isolate the vibration in the tool body from the grip surfaces

To isolate the handles from the vibration in the tool body is the most common thing to do. Modern chain saws and breakers are examples where this principal have been successfully applied. The mass spring system must be designed to have the excitation frequency from the vibration well above the systems resonance. This requires a certain mass in the handles or the spring need to be very soft. A correlated problem is when mass is moved from the body of the tool to the handles. The reduced mass will make the tool-body more sensitive to the vibrating forces and the vibration amplitude in the body will increase.

Summary

An industrial powertool can in most cases be regarded as a rigid body. The handles are not always part of this rigid body.

- Forces acting on this rigid body are the source of vibration. The forces are either forces from the process or process independent e.g. unbalances in rotating parts.
- There are three basic principals for vibration control. Control the magnitude of the vibrating forces. Make the tool less sensitive to the forces. Isolate the vibration in the tool body from the grip surfaces.
- All three principals are used in vibration control on power tools either one by one or combined on the same tool.